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AHA

ADVANCED ROTORCRAFT TECHNOLOGY AND TILT ROTOR WORKSHOPS

DECEMBER 2-5, 1980
PALO ALTO, CALIFORNIA

VOLUME VII
Tilt Rotor Session

HAA/NASA

TILT ROTOR WORKSHOP

December 2, 1980
Palo Alto, California

VOLUME VII

VOLUME VII

TILT ROTOR SESSION

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HAA/NASA TILT ROTOR WORKSHOP

CHAIRMAN'S REPORT

CHAIRMAN	John Magee	NASA-Ames Research Center
TECHNICAL SECRETARIES	James Lane	NASA-Ames Research Center
	Demo Guilianetti	NASA-Ames Research Center
HAA LIAISON	Glen A. Gilbert	HAA-Washington, D.C.

Volume VII presents the results of the Tilt Rotor Workshop. Following a demonstration flight of the XV-15 tilt rotor aircraft at Ames Research Center in the morning session of the workshop, a discussion of the technical characteristics of the aircraft was conducted by the chairman. These are detailed in this volume along with a summary of the discussions, including questions, answers and statements by participants.

OVERVIEW OF PRESENTATION

- PROGRAM OBJECTIVES
- "PROOF-OF-CONCEPT" & CONCEPT EVALUATION
- ACTIONS TAKEN TO INVOLVE MILITARY & CIVIL COMMUNITY
- RESULTS OF THOSE ACTIONS
- SCHEDULE FOR 1981/82
- TEST DESCRIPTIONS

NASA/ARMY/NAVY PLAN OBJECTIVES (SEPT 1979)

- DEMONSTRATE THE ACHIEVEMENT OF THE AIRCRAFT DEVELOPMENT PROGRAMS' PRIMARY OBJECTIVES DURING PROOF-OF-CONCEPT FLIGHT TEST, I.E., VERIFY ROTOR/PYLON/WING DYNAMIC STABILITY OVER THE ENTIRE ENVELOPE, ESTABLISH SAFE OPERATING ENVELOPE LIMITS AND DOCUMENT THE AIRCRAFT PERFORMANCE CHARACTERISTICS WITHIN THAT ENVELOPE, PROVIDE AN INITIAL HANDLING QUALITIES ASSESSMENT, INVESTIGATE GUST SENSITIVITY, AND INVESTIGATE THE EFFECT OF DISC LOADING AND TIP SPEED ON DOWNWASH AND NOISE
- THOROUGHLY EVALUATE THE FLYING QUALITIES AND TERMINAL AREA CAPABILITIES OF THE TRRA
- EVALUATE THE POTENTIAL OF THE TILT ROTOR CONCEPT TO PERFORM MILITARY AND CIVIL MISSION PROFILES
- PROVIDE ADEQUATE DESIGN AND OPERATIONAL DATA UPON WHICH CERTIFICATION CRITERIA AND DESIGN STANDARDS CAN BE BASED

PROOF-OF-CONCEPT & CONCEPT EVALUATION

PROOF-OF-CONCEPT

- BASIC ENGINEERING TESTING TO PROVE THE CONCEPT WORKS

CONCEPT EVALUATION

- TESTING AIMED AT EVALUATING THE USEFULNESS OF TILT ROTOR TECHNOLOGY

ACTIONS TAKEN TO OBTAIN MILITARY & CIVIL COMMUNITY INVOLVEMENT

- o MILITARY USER WORKSHOP (4 DEC 1979)
  - FEEDBACK IDENTIFIED EXPERIMENTS
  - PRELIMINARY IDENTIFICATION OF TEST RANGES & EQUIPMENT
  - USER PARTICIPATION IN DETAILED TEST PLANNING
- o CIVILIAN TILT ROTOR WORKSHOP (2 DEC 1980)
  - INPUT TO FLIGHT EXPERIMENTS PROGRAM SOLICITED FROM INDUSTRY AND ACADEMIC INSTITUTIONS
  - STRAWMAN PLANNING

ISSUES FROM MILITARY USERS

- DOWNWASH (VELOCITY, DEBRIS, WATER SPRAY PATTERNS)
- PILOT WORKLOAD
- MANEUVERABILITY (AIR-TO-AIR, BREAK-LOCK)
- DETECTABILITY
- NIGHT OPERATIONS
- CONFINED AREA/SLOPED LANDING ZONES
- CONTOUR/TERRAIN FOLLOWING AND NAP-OF-THE-EARTH (NOE) FLYING
- ELECTRO-MAGNETIC INTERFERENCE (EMI)
- PLATFORM STABILITY
- SLING LOAD OPERATIONS
- AIR-TO-AIR REFUELING
- "DECK EDGE" EFFECTS & SHIPBOARD OPERATIONS

TILT ROTOR EXPERIMENTS

(BASIC (UNMODIFIED) AIRCRAFT)

SUBJECT/TEST		SUBMITTED BY:
CRITERIA & ENGINEERING DEVELOPMENT DATA		
CERTIFICATION CRITERIA	o CONDUCT TESTS ASSOCIATED WITH FAA CERTIFICATION & ACCUMULATE VTOL/ STOL PERFORMANCE & NOISE DATA	BOEING (GRINA)
	o INVESTIGATE TECHNIQUES FOR ABORTED TAKEOFFS & LANDINGS. DEFINE CRITERIA	BOEING (GRINA)
	o INVESTIGATE EMERGENCY CONDITIONS, INCLUDING CONVERSION AFTER POWER FAILURE AND AUTOROTATION	BOEING (GRINA)
	o DEMONSTRATE NORMAL ACCELERATION & MANEUVER CAPABILITY THROUGH TRANSITION	BOEING (GRINA)

ENGINE DESIGN DATA	o COLLECT ENGINE POWER TIME HISTORIES (TRANSIENTS, CYCLIC, STEADY) & ASSESS DAMAGE CONTENT OF MECHANICAL AND THERMAL LOW CYCLE FATIGUE MODES - SUGGESTED MISSIONS - OIL PLATFORM RESUPPLY, IFR CRUISE, GCA APPROACH, VERTICAL LANDING	DETROIT DIESEL ALLISON (W. L. MC INTIRE)
IFR	o PERFORM HOODED CONVERSIONS & RECONVERSIONS TO ASSESS WORKLOAD	BELL (ROD WERNICKE)
	o PERFORM HOODED INSTRUMENT APPROACHES & TOUCHDOWNS *	BELL (ROD WERNICKE)
NOISE	o NEAR AND FAR FIELD NOISE MEASUREMENTS TO DETERMINE POTENTIAL FOR COMMUNITY NOISE PROBLEMS	AMERICAN AIRLINES (RICHARD LINN)

STOL OPERATION	o DEMONSTRATE RAPID ACCELERATION & DECELERATION FOR MINIMUM RUNWAY LENGTH, EXAMINE V_{MIN} CONTROL	BELL (ROD WERNICKE)
NAVIGATION	o NAVIGATE ON DISCRETE NARROW WIDTH R_{NAV} ROUTES. QUALIFY FTE (FLIGHT TECHNICAL ERROR)	GLEN GILBERT (HAA)
NAV/TERMINAL AREA	o EVALUATE TRANSITION FROM VTOL (HELICOPTER) TO CTOL (AIRPLANE) & CTOL TO VTOL IN TERMINAL AREA ENVIRONMENTS UNDER ATC PROCEDURES. USE R_{NAV} SID'S & STAR'S	GLEN GILBERT (HAA)
	o EVALUATE TRANSITION FROM CTOL TO VTOL ON INSTRUMENT APPROACHES. PERFORM PRECISION & NONPRECISION APPROACHES *	GLEN GILBERT (HAA)

NAV/TERMINAL AREA (CONT.)	o PERFORM MISSED APPROACH INSTRUMENT PROCEDURES.* DETERMINE AIRSPACE REQUIREMENTS, BOTH AS VTOL AND IN TRANSITION VTOL TO CTOL	GLEN GILBERT (HAA)
	o EVALUATE TERPS CRITERIA IN RELATION TO VTOL & CTOL PERFORMANCE	GLEN GILBERT (HAA)
	o DETERMINE MINIMUM AIRSPACE REQUIRED FOR HOLDING AS A VTOL	GLEN GILBERT (HAA)
	o EVALUATE EFFECTS OF ATC SPEED CONTROL IN TERMS OF VEHICLE PERFORMANCE AND TIME RESPONSE REQUIREMENTS	GLEN GILBERT (HAA)
	o AUTOMATIC GUIDANCE SYSTEM (REQUIRES V/STOLAND INSTALLATION)	SPERRY (R.H. WAGNER)

CIVIL MARKET APPLICATIONS

OFFSHORE OIL PLATFORM	o DEMONSTRATE HANDLING QUALITIES IN OIL RIG & SHIP ENVIRONMENTS - E.G. INVESTIGATE CONTROL REQUIREMENTS & HQ WITH ROTOR PARTIALLY OVER EDGE OF PLATFORM OR DECK AND OPERATION IN TURBULENCE	BELL (R. WERNICKE) & BOEING (GRINA)
COMMUTER AIRLINE	o PERFORM ELEMENTS OF COMMUTER AIRLINE FLIGHT PROFILES (CLIMB, DEPARTURE, CRUISE, DESCENT, HOLDING, ETC). ASSESS PASSENGER, USER, & COMMUNITY ACCEPTANCE	BHT (R. WERNICKE) & BOEING (GRINA)
	o SIMULATE SCHEDULED OPERATION TO DEVELOP IN-SERVICE DATA ON PASSENGER HANDLING, NOISE, EFFECT ON WAKE ON LIGHT AIRCRAFT IN VICINITY, ETC.	BOEING (GRINA)

TECHNOLOGY	o CONTINUE THE EMPHASIS ON SOLVING THE STRUCTURAL DYNAMICS DIFFICULTIES, INCLUDING THOSE YET TO BE UNCOVERED DURING THE ENVELOPE EXPANSION TESTS. EVEN THOUGH SOME OF THESE SOLUTIONS MAY BE VEHICLE SPECIFIC, THEY ARE IMPORTANT FOR CORRELATION PURPOSES TO PROVE OUR ANALYTICAL METHODOLOGY.	BELL (S. MARTIN)
	o AS A CONTRIBUTION TO THE ABOVE, WE NEED TO INSTALL THE STIFFER CONVERSION SPINDLES AS SOON AS THE PROGRAM SCHEDULE WILL ALLOW.	BELL (S. MARTIN)
	o LATER IN THE PROGRAM SCHEDULE, WE SHOULD TRY A REDUCED TAIL SIZE, SINCE IT IS RELATIVELY EASY TO DO, WILL SAVE WEIGHT. AND SHOULD GREATLY REDUCE THE TAIL BUFFET THAT OCCURS DURING CONVERSION. EVENTUALLY, WE MIGHT TRY A SINGLE VERTICAL FIN TAIL CONFIGURATION AND PERHAPS A T-TAIL.	BELL (S. MARTIN)

TECHNOLOGY (CONT.)	o THE ADVANCED TECHNOLOGY BLADES NOW UNDER EVALUATION BY NASA OFFER SUBSTANTIAL IMPROVEMENTS IN STATIC THRUST, PROPULSIVE EFFICIENCY, AND DYNAMIC STABILITY. THIS PROGRAM SHOULD MOST CERTAINLY BE PURSUED AGGRESSIVELY, REGARDLESS OF WHO WINS THE COMPETITION.	BELL (S. MARTIN)
	o FLY-BY-WIRE OR LIGHT CONTROLS, PERHAPS TIED IN WITH THE V/STOL AND NASA PROGRAM, WOULD OFFER INTERESTING POSSIBILITIES TO NOT ONLY REDUCE THE WEIGHT EMPTY, BUT ENHANCE THE HANDLING QUALITIES AND ENABLE A NUMBER OF INTERESTING EXPERIMENTS IN ADAPTIVE CONTROLS TO BE PERFORMED.	BELL (S. MARTIN)

AIRCRAFT STATUS

702 (AT ARC)

- o REFURBISHMENT COMPLETE
- o GROUND RUNS CONDUCTED
- o FLIGHT STATUS: IN CHECKOUT PHASE

703 (AT DFRC)

- o REASSEMBLED AFTER SHIPMENT FROM BHT
- o GROUND RUNS COMPLETE
- o FIRST FLIGHT AT DFRC - 10 OCT 80
- o TOTAL FLIGHT TIME AS OF 23 OCT - 67.4 HRS
- o DAMAGE FRACTION: 0.75%
- o DD250 ACCOMPLISHED - 30 OCT 80

XV-15 PROPOSED TEST SCHEDULE

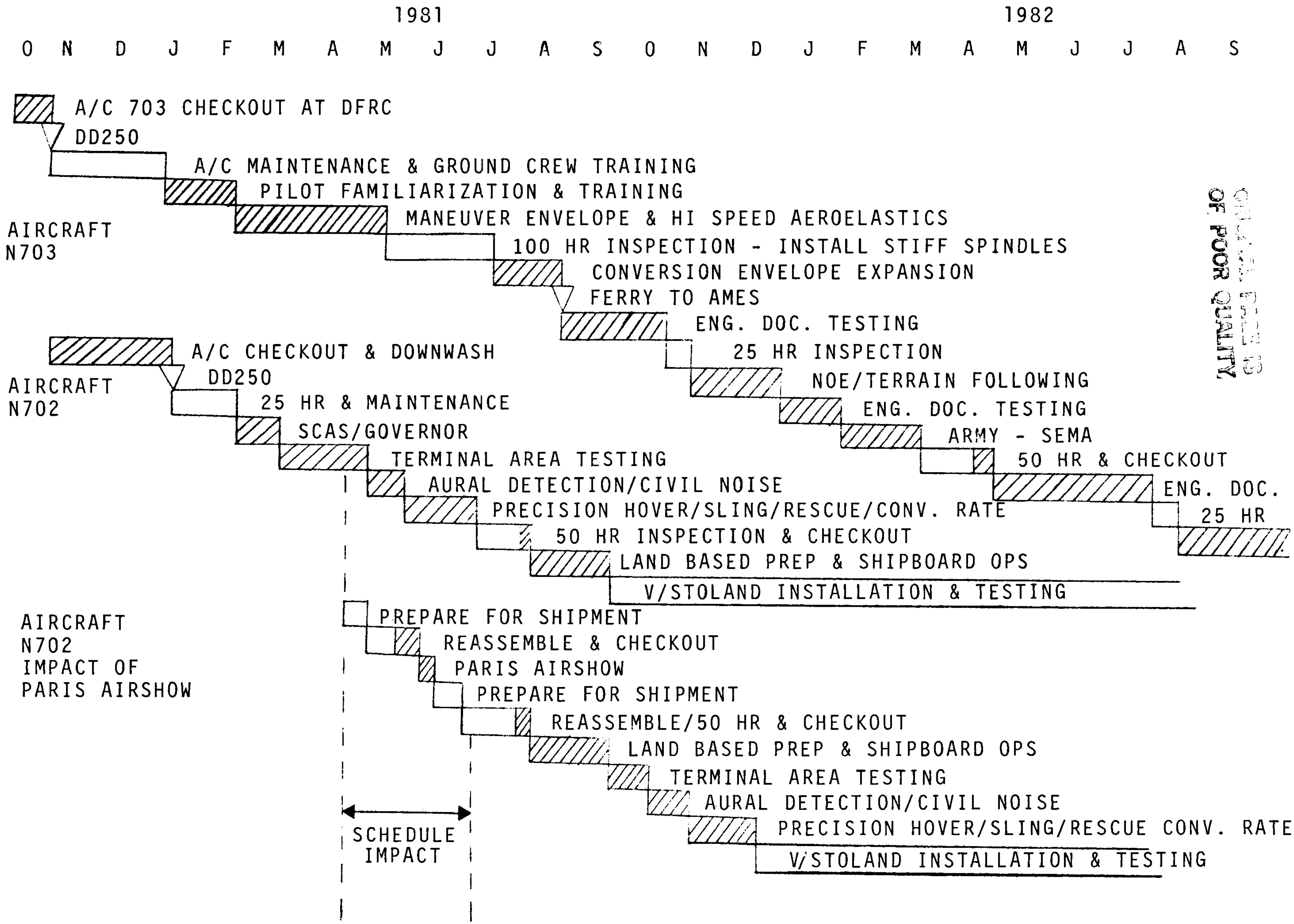


TABLE 2. GOVERNMENT XV-15 TEST MATRIX SUMMARY FOR "PROOF-OF-CONCEPT" AND AIRCRAFT DOCUMENTATION

2.0 CHECKFLIGHTS AND AIRSPEED CALIBRATION

3.0 SINGLE ENGINE HEIGHT/VELOCITY ENVELOPE

4.0 CONVERSION CORRIDOR EXPANSION - HOVER

i_N = 90, 75, 60, 30 AND 0°, 13,000 LBS. AFT CG
i_N = 90, 75, 60, 30 AND 0°, 13,000 LBS. FWD CG
i_N = 90, 75, 60, 30 AND 0°, 15,000 LBS. AFT CG

5.0 AEROELASTIC STABILITY

EFFECT OF FLAPS/RPM AT END CONVERSION
AIRSPEED EFFECTS 5,000 FT. ALT.
AIRSPEED EFFECTS 10,000 FT. ALT.
AIRSPEED EFFECTS 15,000 FT. ALT.
EFFECT OF SCAS
WINDMILLING DESCENTS 160/180 KTS.
EFFECT OF CG POSITION 10,000 FT. ALT.

6.0 MANEUVER ENVELOPE EXPANSION

WINDUP TURNS i_N = 90, 75, 60, 30, 0°, 13,000 LBS. AFT.
PULLUP/PUSHOVERS i_N = 90, 75, 60, 30, 0°, 13,000 LBS. AFT.
WINDUP TURNS i_N = 90, 75, 60, 30, 0°, 13,000 LBS. FWD.
PULLUPS/PUSHOVERS i_N = 90, 75, 60, 30, 0°, 13,000 LBS. FWD.

7.0 STATIC STABILITY (LONGITUDINAL & LATERAL DIRECTIONAL)

ALL SYSTEMS OPERATING, 13,000 LBS. AFT.
FORCE FEEL OFF/SCAS OFF, 13,000 LBS. AFT.
ALL SYSTEMS OPERATING, 13,000 LBS. FWD.
FORCE FEEL OFF/SCAS OFF, 13,000 LBS. FWD.
ALL SYSTEMS OPERATING, 15,000 LBS. AFT.

TABLE 2. (CONT.)

8.0	DYNAMIC STABILITY (AIRCRAFT RIGID BODY) LONGITUDINAL/LATERAL/DIRECTIONAL 13,000 LBS. AFT. LONGITUDINAL/LATERAL/DIRECTIONAL 13,000 LBS. FWD.
9.0	CONTROLLABILITY LONGITUDINAL/LATERAL/DIRECTIONAL 13,000 LBS. AFT. CG LONGITUDINAL/LATERAL/DIRECTIONAL 13,000 LBS. AFT. CG
10.0	HOVER PERFORMANCE BASELINE HOVER PERFORMANCE SF = 40, GW = 12,500, 13,000, 15,000 OGE/IGE EFFECT OF RPM EFFECT OF FLAPS
11.0	TAKEOFF/LANDING PERFORMANCE HOVER - IGE LEVEL ACCELERATION 13,000 LBS. AFT. ROLLING TAKEOFF 15,000 LBS. AFT. ROLL-ON LANDINGS 15,000 LBS. AFT.
12.0	SAWTOOTH CLIMB/DESCENT PERFORMANCE CLIMBS/DESCENTS 13,000 LBS. AFT. $i_N = 90, 75, 60, 30, 0^o$ AT VARIOUS AIRSPEEDS
13.0	LEVEL FLIGHT PERFORMANCE 13,000 LBS. AFT. CG $i_N = 90, 75, 60, 30, 0^o$ $V = 0$ TO V_{MAX} AT 5,000, 10,000, 15,000 FT. ALT.

IN ADDITION TO THE ABOVE, DOWNWASH/GROUNDWASH AND ACOUSTIC DATA IN HOVER OGE AND IGE IS PLANNED FOR NOVEMBER/DECEMBER 1980 IN CONJUNCTION WITH HOVER MEASUREMENTS AND DOWNWASH DATA REQUESTED BY VARIOUS USER ORIENTED GROUPS.

TILT ROTOR CONCEPT EVALUATION (HOVER)

CONCERN - HOVER DOWNWASH (ROTOR WAKE) EFFECTS ON:
GROUND OPERATIONS & PERSONNEL
SURFACE ERROSION/DISTURBANCE (FOD, FIRE, DUST)

CONCERN - HOVER NOISE LEVEL (GROUND OBSERVER & CREW)

CONCERN - HOVER PERFORMANCE
GROUND EFFECT
OGE ROTOR EFFICIENCY

APPROACH - COMBINED HOVER DOWNWASH, ACOUSTICS, PERFORMANCE EVALUATION

TILT ROTOR CONCEPT EVALUATION (HOVER) (CONT.)

METHOD - FREE HOVER (2 FT TO 50 FT H) & TIEDOWN TESTS

MEASURE FLOW DISTRIBUTION & NOISE LEVEL AROUND HOVERING XV-15

RECORD CREWSTATION NOISE (FOR EVALUATION & SIMULATION)

VARY FLAP ANGLE, RPM, NACELLE ANGLE

VARY ROTOR TORQUE & RPM ON TIE-DOWN

MEASURE GROUND LEVEL TEMPS

PLANNED RESULTS - MAP DOWNWASH VELOCITY AND DIRECTION BELOW HOVERING TILT ROTOR - ASSESS EFFECTS OF FLAPS, NACELLE ANGLE

MAP NOISE SIGNATURE - ASSESS EFFECTS OF ROTOR RPM

CREWSTATION NOISE AVAILABLE FOR T/R SIMULATION

CORRELATE TIEDOWN DOWNWASH, ACOUSTICS, & PERFORMANCE DATA TO FREE HOVER

ASSESS EFFECTS OF DISC LOADING & TIP SPEED

MAP SURFACE TEMP. DISTRIBUTION BELOW ENGINES

SCAS/GOVERNOR TESTS & EVALUATIONS

- o SCAS
  - IMPROVED CONTROL RESPONSE
  - IMPROVED DISTURBANCE REJECTION
    - ... MINIMIZE GOVERNOR INSTABILITY
    - ... ELIMINATE "CHUGGING"
- o GOVERNOR
  - REDUCE SYSTEM BANDWIDTH TO MINIMIZE CROSS-SHAFT DYNAMIC COUPLING
  - IMPROVE PERFORMANCE IN REGION OF GOVERNOR INSTABILITY

TILT ROTOR CONCEPT EVALUATION (PROPULSION)

CONCERN - ENGINE INFLOW IN HOVER
ENGINE VIBRATION ENVIRONMENT
POWER SPECTRUM & TIME HISTORIES

APPROACH - EVALUATE ENGINE CONDITIONS THROUGHOUT FLIGHT ENVELOPE

METHOD - INSTALL TEMP. SURVEY RAKE AT ENGINE INLET
RECORD INFLOW TEMPS. IN HOVER AT VARIOUS HEIGHTS AGL
RECORD NACELLE ACCELERATIONS (ALL FLIGHT MODES)
RECORD POWER LEVELS & TIME HISTORIES (ALL FLIGHT MODES)

PLANNED RESULTS - BASELINE ENGINE DESIGN DATA

XV-15 TERMINAL AREA OPERATION

- TAKEOFF/DEPARTURES
  - ABORT TECHNIQUES - ACCEL/DECEL CAPABILITY
  - ENGINE OUT PROCEDURES
- HOLDING PATTERNS/LANDING APPROACHES
  - AIRCRAFT CONFIGURATION
  - NAVIGATION/INSTRUMENTATION REQUIREMENTS
  - NORMAL AND STEEP APPROACHES (STRAIGHT-IN)
  - DECELERATING APPROACHES (APPROACH CONVERSIONS)
  - MANEUVERS DURING APPROACHES
  - MISSED APPROACHES/GO-AROUND PROCEDURES
- LANDINGS
  - TERMINATE IN HOVER FROM VARIOUS APPROACH ANGLES
  - ROLL-ON LANDINGS - NACELLE ANGLES FROM 90° TO 60°
  - SINGLE ENGINE LANDING TECHNIQUES
- ACOUSTICS
  - HOVER/AIRPORT OPERATIONS SOUND LEVELS
  - DEPARTURE PATH SOUND LEVELS
  - APPROACH PATH SOUND LEVELS

XV-15 SLING LOAD/RESCUE OPERATIONAL CAPABILITY

- o BASED ON POC DATA (IGE AND OGE)
  - POWER REQUIRED VS GROSS WEIGHT
  - DOWNWASH VELOCITY VS POWER/THRUST
  - DOWNWASH FLOW PATTERNS
  - PILOT WORKLOAD
- o SLING LOAD/RESCUE DEMONSTRATION (CALM & TURBULENT WIND CONDITION)
  - PRECISION HOVER CAPABILITIES
    - ... SCAS CONFIGURATION REQUIREMENTS
    - ... OUTSIDE REFERENCE REQUIREMENTS
    - ... COCKPIT REFERENCE REQUIREMENTS
  - AIRCRAFT/GROUND CREW OPERATION
    - ... DOWNWASH VELOCITIES
    - ... DOWNWASH FLOW PATTERNS
    - ... NOISE LEVELS
    - ... AIRCRAFT/GROUND CREW COMMUNICATIONS
  - DECK EDGE/OIL RIG PLATFORM OPERATION
    - ... AIRCRAFT RESPONSE TO RAPID IGE/OGE CONDITIONS
    - ... AIRCRAFT RESPONSE TO DECK EDGE TURBULENCE

CONVERSION SYSTEM RATE CHANGES

PRESENT DESIGN

- HIGH RATE OF 7.5°/SEC BASED ON XV-3 AND MAKING RECONVERSION WITH TOTAL POWER FAILURE
- LOW RATE OF 1.5°/SEC USED APPROACHING STOPS (WITHIN 5°)

PROBLEMS

- HIGH RATE REQUIRES "BEEPING" TO KEEP UP WITH AIRCRAFT
- LOW RATE IS TOO SLOW

AREAS FOR INVESTIGATION

- REDUCED HIGH RATE TO 5°/SEC
- CONTROL COUPLING WITH CONVERSION TO AID PILOT

LAND-BASED PREPARATION FOR SHIPBOARD TESTS

- o TURBULENCE EFFECTS ON HANDLING QUALITIES
  - USE HANGER WAKE TO SIMULATE SUPERSTRUCTURE TURBULENCE
- o DECK EDGE EFFECTS
  - SIMULATED DECK (STATIC), ONE ROTOR IGE ONE ROTOR OGE CONTROL EFFECTS
- o NAVY FLIGHT CREW TRAINING
- o SIMULATED TAKE-OFF, APPROACH AND LANDING PATTERNS

SHIPBOARD OPERATIONS

- o PLAN TO GO ABOARD LHA
  - NAVY INVESTIGATING SHIP AVAILABILITY
- o INVESTIGATIONS TO INCLUDE:
  - APPROACH, LANDINGS, AND TAKE-OFFS
  - HANDLING QUALITIES IN SUPERSTRUCTURE TURBULENCE
  - SHIP HEADING, WIND-OVER-DECK EFFECTS
  - DECK HANDLING
  - DECK EDGE EFFECTS

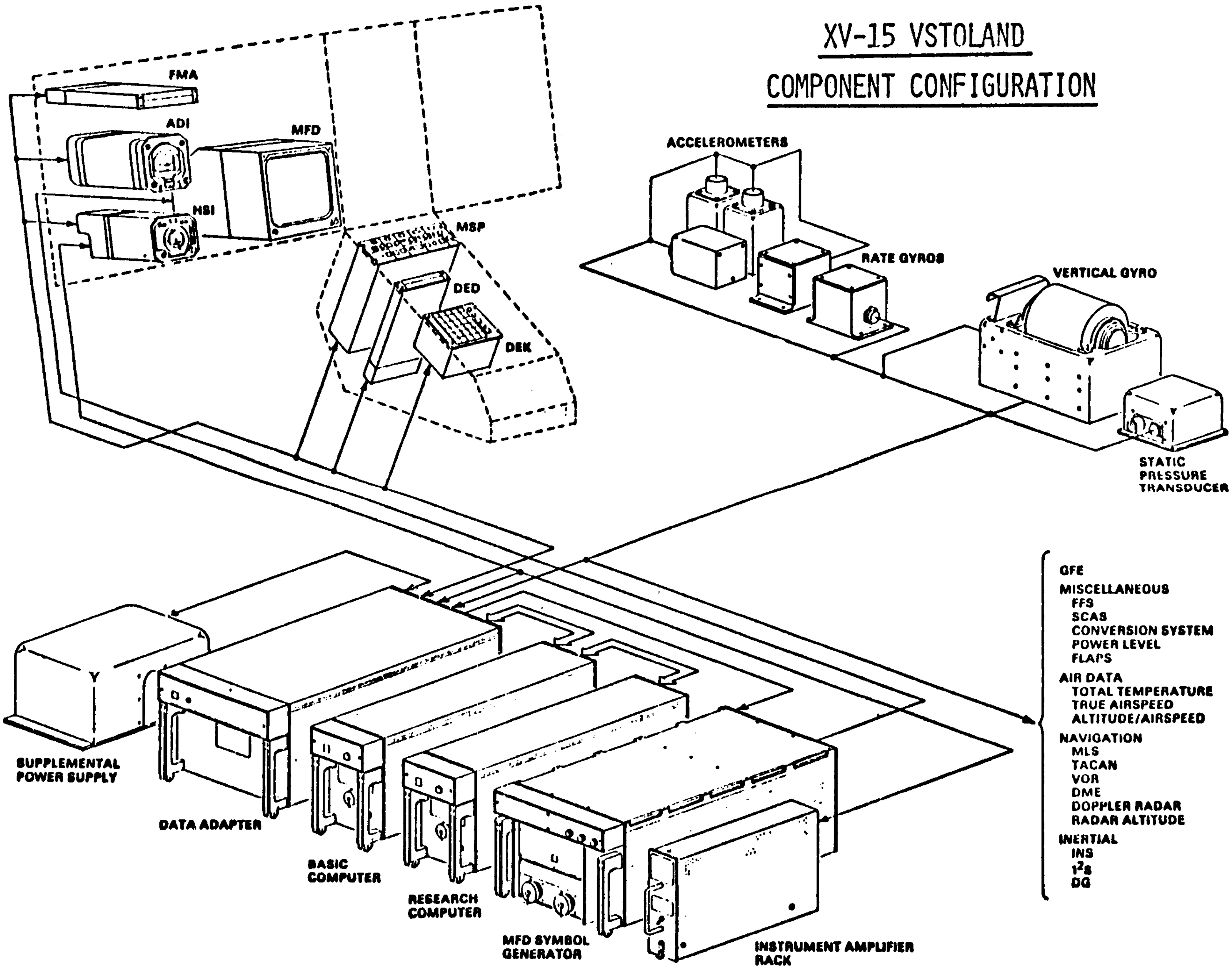
NOE/TERRAIN FOLLOWING

- o EVALUATE RESPONSE IN NOE ENVIRONMENT
- o EVALUATE STABILITY IN MASK-UNMASK-REMASK OPERATION
- o EVALUATE DETECTABILITY (VISUAL, AURAL, RADAR, IR)
- o EVALUATE RESPONSE IN LOW LEVEL FLIGHT
  (HOW LOW CAN YOU GO?)
- o EXPLORE USE OF ACCEL/DECEL ON HOW WE PERFORM
  NOE FLIGHT

SEMA FLIGHT PROFILES

- o TRADOC/INTELLIGENCE SCHOOL EFFORT
- o FLY SEMA PROFILES
- o EVALUATE SURVIVABILITY VIS-A-VIS CURRENT SEMA AIRCRAFT
- o INNOVATIVE WAYS OF PERFORMING SEMA MISSIONS

XV-15 VSTOLAND COMPONENT CONFIGURATION



ADVANCED ROTORCRAFT OPERATING SYSTEMS
XV-15 PROGRAM OBJECTIVES

ELEMENT	OBJECTIVE
VSTOLAND SYSTEM FOR XV-15	INSTALL & CHECKOUT INTEGRATED DIGITAL AVIONICS FLIGHT RESEARCH SYSTEM FOR TILT-ROTOR
XV-15 TERMINAL AREA NAVIGATION	DEVELOP & FLIGHT TEST KALMAN FILTER NAVIGATOR WITH BODY MOUNTED & GIMBALLED INERTIAL SYSTEMS FOR TERMINAL AREA FLIGHT RESEARCH
XV-15 COUPLED APPROACHES	EVALUATE COUPLED MLS TERMINAL AREA APPROACHES INCLUDING TRANSITIONS FROM AIRPLANE TO HELICOPTER FLIGHT
FLIGHT DIRECTOR & DISPLAY	DEVELOP AND EVALUATE FLIGHT DIRECTORS & DISPLAYS FOR XV-15 AIRPLANE, TILT-ROTOR & HELICOPTER FLIGHT MODES
XV-15 TAFCOS	DEVELOP AND FLIGHT TEST ADVANCED TAFCOS (TOTAL AUTOMATIC FLIGHT CONTROL SYSTEM) AUTOPILOT FOR TILT ROTOR
4D GUIDANCE EXPERIMENTS	DEVELOP AND FLIGHT TEST MINIMUM FUEL AND NOISE 4D GUIDANCE SYSTEM FOR THE TILT-ROTOR

NASA/HAA Tilt Rotor Workshop
December 2, 1980

Panel Session Summary

Panel Members' Comments

Stan Martin, Bell Helicopter

- The Proof-of-Concept tests should be expanded with the objective of providing basic engineering data for an identified customer/user.

- More emphasis and priority should be given to developing analytical tools and documenting and understanding tilt rotor structural dynamics.

- Rotor whirl flutter has been resolved but fixes for pylon vibration including stiff conversion spindles, soft pylon downstop and rotor phasing, should be implemented and the results analyzed.

- Short term specfic recommended hardware changes should include the following:

  - stiff spindle installation
  - tail size reduction or single fin T-Tail
  - advanced technology blade procurement and installation.

- Long term considerations should include the following:

  - empty weight reduction for increased productivity
  - fly-by-wire control system development that can perhaps be tied to VSTOLAND
  - composite wing development for weight reduction and frequency tailoring.

- Both aircraft should be kept actively flying to learn as much as possible as soon as possible.

Bill Peck, Boeing Vertol

- Record-keeping should be given special emphasis for the specific purpose of evaluating maintainability and reliability.

- Vibration should be measured and evaluated for areas other than the cockpit, e.g., nacelles. There is some increase in the complexity of a Tilt Rotor compared to a helicopter, but the aircraft components may be exposed to a much quieter environment.

- Nap-of-earth and terrain following tasks should be included in your simulation program.

- The Tilt Rotor will have a hard time competing for funds in the environment of the steady reduction of new configuration starts that has existed since the 1960's, and it will need tri-service program support. Commercial operators are not capable of providing the required development money.

Tom West, FAA

- Either new design criteria for certification will have to be established or we will have to develop techniques for adapting the present regulations.

- Shipboard operations should be investigated in conjunction with sling loading for requirements such as off loading ships in port.

Glen Gilbert, HAA

- Tilt Rotor operations and applications that should be stressed include productivity, economic advantages, benefits for military and civilian communities and special emphasis should be given to the concept of augmenting our total transportation system.

- Operational tests are recommended for the development of a data base that would show advantages of the Tilt Rotor in the utilization and conservation of existing airspace.

- Joint tri-service involvement and support are needed for operational development of the aircraft.

Bill Thompson, Air Logistics

- Shipboard operations should include off-shore oil tasks. Air Logistics is willing to support later operational tests at their site.

- Noise level data for the Tilt Rotor is important to airport operators and special emphasis should be given to commuter airline operations.

<u>Comments From Floor</u>

Joe Gross, Mobil Oil Co.

- Rotor blade deicing experiments should be considered.

Bob Suggs, Petroleum Helicopters

- With respect to icing/deicing of rotor blades, the technology is already available, why don't we have the blades?

Ken Rosen, Sikorsky Aircraft

- For certification to Cat. A, rotor governing should be investigated (absorption vs demand systems) in relation to engine failure.

Frank McQuire, Helicopter News

- Where do the Tilt Rotor and ABC aircraft overlap? What are their differences in the capability of doing various jobs?

Ed Cohen, Hughes Aircraft

- NASA should devote its efforts to working on Tilt Rotor unique problems and let industry work on the development problems. How much extrapolation is available for problem solving and is adequate data available?

Commander Buddick, USCG

- Sling hoist tests should be conducted over water.

Arnie Brooks, General Electric

- Engine failure strategies and thrust power management control strategies must be considered for multi-mode operations.

Other

- What is your achievable weight fraction? Design studies are needed for a production configuration.

- What are your specific plans for sling hoist tests, such as rescue hoists?

- Are you attempting to quantify your load predictions? Are you developing fatigue prediction methods?

Written Questions and Comments

Ray Malantino, FAA

- What, if any, theoretical, model tests or flight tests have been done or are planned to be done with regard to store stations on the wing? e.g., military usage could call for the carrying of bombs, torpedoes, fuel tanks, etc., also the civilian usage could call for fuel tanks.

- Discussions with regard to future "special condition" on the "type certification" should be started if and when a type certification comes about in the future.

- Eventually, work with regard to "icing" must be performed.

Henry J. Christiansen, FAA

- NASA should undertake as much as possible of the work leading toward certification for civilian use.

- Following needed certifications, NASA should support operational demonstrations in an Air Traffic Control system that integrate helicopter and tilt rotor IFR operations.

Bill Baker, Tenneco Oil Company

- Crosswind landings and takeoffs (30-35K+) should be evaluated, and the effects of air flow across the upwind rotor on the other rotors evaluated.

- A minimum size heliport should be used for operations at maximum gross weight:

  - offshore rigs.
  - elevated platform (such as rooftop).

Col. H.B. Snyder, USA

- Flight evaluations should include tri-service commonality requirements leading to a second phase tilt rotor program.

- Include new techniques, composites, advanced engines and flight control.

James T. Cheatham, Verticare

- How do manufacturing costs compare to similar sized helicopters (acquisition cost)?

- Can the test aircraft be fitted with a cargo hook?

- Flight evaluations should include 180^{o} turns as would apply to agricultural operations.

- External load performance should be evaluated.

Roger Baker

- Development should include a closed loop with NASA/FAA/DOD in the areas of certification, engineering and manufacturing, piloting and maintenance.

Art Hanley, FAA

- What is the tilt rotor capability for sustained helicopter mode flight?

- What are the effects of heavy rain or normal airport FOD in hovering and slow speed flight?

- Flight evaluations should include airport operations with other aircraft, ground and air taxi, touch and go, various pattern entries (downwind, base, overhead, CTOL approach with VTOL landing on ramp) and operations to determine optimum points for transition.

- Flight investigations should include VFR approaches and effects of heavy jet wake turbulence on Tilt Rotor during CTOL, VTOL, and transition, both parallel and perpendicular to line of flight.